Fisheries and Oceans Science | Pêches et Océans Sciences

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Proceedings Series 2001/15 | **Série des compte rendus 2001/15**

Report of the PSARC Invertebrate Subcommittee Meeting, June 19-21, 2001

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Nanaimo, British Columbia V9R 5K6

July 2001

Canada

102-00679/

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 2001-03
JULY 2001

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SUMMARY

The Pacific Scientific Advice Review Committee (PSARC) Invertebrate Subcommittee met 19 June to 21 June, 2001 in the Seminar Room at the Pacific Biological Station in Nanaimo, B.C. The Subcommittee reviewed five working papers, five Fishery Updates, and three stock status reports.

Working Paper I2001-01: A phase "0" review of inshore tanner crab (*Chionoecetes bairdi*) biology

** Not accepted **

Working Paper I2001-02: Results of surveys of intertidal razor clams (*Siliqua patula*) on beaches near Massett, Haida Gwaii and recommendations on fishery management

** Accepted subject to revisions **
Intertidal razor clam populations and biomass on beaches near Massett, Haida Gwaii were estimated using a three stage sampling design stratified by beach section for the period 1994 to 2000. The year 2000 biomass of clams > 90 mm was estimated to be 1,757 t (SE 161 t). The surveys show that the biomass was at an historic high in 2000 and that a large number of two year old clams were in the population, most of which will recruit to the fishery in 2001. The Subcommittee accepted the results of the analyses indicating a large biomass of razor clams was present in 2000 and that the 2001 catch ceiling (235.8 t) was within the range of estimates based on a 12.3% harvest rate (160 - 237 t). The Subcommittee recommended that the data collected since 1994 should be analysed to re-evaluate the estimate of maximum sustainable yield (MSY). Until such reanalysis, the Subcommittee recommended using the 12.3% harvest rate and applying this to the current year biomass estimates to obtain current catch ceilings. The Subcommittee did not support removing the size limit without considering the implications or reasons for doing so (economic and/or biological).

Working Paper I2001-03: High levels of genetic variation in northern abalone, *Haliotis kamstchatkana*, of British Columbia

** Accepted subject to revisions **
Northern abalone (*Haliotis kamtschatkana*), from several sites in British Columbia were surveyed for their genetic variation to identify the extent of population differentiation in this species. The results indicate that, historically, northern abalone breeding populations were likely large, that aggregations did not represent isolated breeding units, and any disruption of gene flow that may have been caused by recent low abundance levels cannot yet be detected in non-size-structured samples of adult abalone. There was some evidence to suggest that populations in the Queen Charlotte Islands might have been separate from the

mainland B.C. coast. The Subcommittee accepted the recommendations from the paper regarding preservation of existing brood stock *in situ*; monitoring and evaluation of out-planting techniques; and establishment of study sites for monitoring current population genetics and demographics. The Subcommittee concurred with the paper in recommending that brood stock collections be made within the general regions into which seeding is intended to take place.

Working Paper I2001-04: Assessment of green sea urchin (*Strongylocentrotus droebachiensis*) stocks in British Columbia, 2001

** Accepted subject to revisions **
This paper (i) provides an analysis of the green sea urchin fishery in British Columbia by updating information from the fisheries in 1998, 1999, and 2000 fishing seasons; (ii) provides suggestions for limit and target reference points for the 2001-2002 and 2002-2003 fishing seasons; and (iii) presents results from fishery-independent surveys of green sea urchins. The calculated MSYs were recommended as limit reference points, with target yield options suggested in the range of 0.25 to 0.50 of MSY (96.3 to 192.5 t). The Subcommittee endorsed these recommendations for yield options. The Subcommittee supported the recommendation that fishery-independent surveys should continue in Area 12; that a site should be selected to develop annual surveys in the Gulf Islands areas; and that experimental studies on growth rates and age determination should continue.

Working Paper I2001-05: Status of manila clam (*Venerupis philippinarum*) stocks in Area 7, with a proposal for active management of a data limited fishery.

** Accepted subject to revisions **
This paper examines fishery-dependent and independent survey data collected over the past two years to determine stock status of Manila clams in this area. It proposes application of the Magnussen-Stefansson feedback gain model to determine catch thresholds. Two options were discussed – adjustment of the overall Area 7 TAC based on the aggregate results, and establishment of harvest thresholds for individual subareas which would allow opportunity to harvest the remainder of the TAC from underutilized subareas. The Subcommittee accepted the recommendations from the paper concerning adopting subarea in-season catch thresholds, a review of the appropriateness of current index beaches, establishment of index beaches in subareas not currently assessed, and acknowledgement that continued reductions in subarea thresholds will require re-assessment of the overall Area 7 TAC.

Fishery Updates

Fisheries Management staff, in consultation with Conservation and Protection and Stock Assessment Divisions, prepare fishery updates. The updates provide

summaries of commercial fishery performance, including significant management, enforcement, and stock assessment activities on an annual basis. The updates provide the opportunity to identify high priority issues that affect assessments and conservation concerns. The fishery updates for euphausiids, sea cucumbers, shrimp by trawl, goose barnacles, and intertidal clams were presented at this meeting.

Emerging Issues

Two emerging issues were identified by the Subcommittee during its deliberations:

Cross-species interactions:
Interactions across species groups (e.g. invertebrates and finfishes, marine mammals) and across governmental jurisdictions have become important for several invertebrate species, yet there is no mechanism for formal evaluation and presentation of these interactions. Some of the issues discussed were: the impacts of expanding sea otter populations and their predation on invertebrates, management of eulachon by-catch issues in the shrimp trawl fishery, and expanding aquaculture leases licensed by the Province, which may impact biodiversity and ecosystem approaches to management in areas where aquaculture is intensely developed. A working group to address the expanding stock assessment issues relating to interactions across species groups is urgently needed. Concerning the aquaculture and intertidal clam fishery issue, more coordination, discussion, and broadening of the aquaculture referral process within DFO to include consideration of ecosystem impacts is recommended.

Difficulties with assessment and management at small spatial scales:
The assessment and management of many invertebrate species is moving to smaller spatial scales. This presents problems for the Department's ability to collect data at these small scales, to evaluate these data, and for fisheries managers to react to potential concerns in a timely manner. Fisheries and Oceans Canada (DFO) needs to recognise the problems generated by harvesting and managing at small spatial scales, and to develop the tools and expertise to resolve these issues. At the extreme, it may require DFO to acknowledge that, at least for some species, assessment and management at these small scales will not be feasible.

INTRODUCTION

The PSARC Invertebrate Subcommittee met at the Pacific Biological Station in Nanaimo, B.C., from 19-21 June, 2001. The Subcommittee Chair opened the meeting by welcoming the participants. He provided introductory remarks on the roles and responsibilities of the Subcommittee, and the roles and responsibilities of external participants and observers. The Subcommittee accepted the agenda

(Appendix 1). During its proceedings, the Subcommittee reviewed five working papers (Appendix 2), five fishery updates, and three stock status reports. This Advisory Document provides the record of the Subcommittee's deliberations and recommendations.

A number of external participants and observers attended the meeting. All participants at the meeting and the days they attended are presented in Appendix 3.

EMERGING ISSUES

Two issues emerged from the meeting for special consideration:

1. Cross-species interactions:
Issue: Interactions across species groups (e.g. invertebrates, finfishes, and marine mammals) and across governmental jurisdictions have become important for several invertebrate species, yet there is no mechanism for formal evaluation and presentation of these interactions.

Discussion: Interactions among species groups, and development of some formal mechanism to review and consider these, were discussed in regards to potential impacts of expanding sea otter populations and their predation on invertebrates, and with management of eulachon by-catch issues in the shrimp trawl fishery. It was noted that shrimp fishery managers and Stock Assessment staff feel they will be put in a position of evaluating the effectiveness and impacts to eulachon populations of modifications to shrimp fishing gear.

In addition, species interactions and interactions among governmental jurisdictions was an issue for intertidal clams, in which expanding aquaculture leases licensed by the Province may be negatively impacting biodiversity and ecosystem approaches to management.

The Subcommittee noted that these are issues which require expertise outside of the invertebrate groups. The Subcommittee noted further that this issue has been brought forward previously as a concern, but there appears to have been no action to date.

Recommendations: A working group to address the expanding stock assessment issues relating to interactions across species groups is urgently needed. Concerning the aquaculture and intertidal clam fishery issue, more coordination, discussion, and broadening of the aquaculture referral process within DFO to include consideration of ecosystem impacts is recommended.

2. *Difficulties with assessment and management at small spatial scales:*
Issue: The assessment and management of many invertebrate species is moving to smaller spatial scales. This presents problems for DFO's ability to collect data

at these small scales, to evaluate these data, and for fisheries managers to react to potential concerns in a timely manner.

Discussion: For several reasons, there is increasing interest on the part of fishing industries and within DFO to move to assessing and managing many invertebrate species at smaller and smaller spatial scales. The move to assess and manage manila clams in Area 7 almost on a beach by beach basis is an example from this current PSARC meeting. However, operating at these small spatial scales presents great difficulties not only for the collection of stock assessment and fishery data, but also for the timely flow of these data to Stock Assessment Division and Fish Management staff, and the ability for DFO to respond and industry to comply. These difficulties are further exacerbated by the remote location of many of these small scale activities. As the spatial scales of assessment and management become smaller, there is a need for the time scales of both these to become shorter. However, for the most part, DFO does not have the reporting or data analyses systems (and in some cases, techniques) available for these short time and space scales.

Recommendation: DFO needs to recognise the problems generated by harvesting and managing at small spatial scales, and to develop the tools and expertise to resolve these issues. At the extreme, it may require DFO to acknowledge that, at least for some species, assessment and management at these small scales will not be feasible.

Although not an Emerging Issue as such, in discussions on a number of species the Subcommittee noted the need to develop Assessment Frameworks. These frameworks would evaluate the present condition of the stock against the stock condition and assessment and management contexts for what DFO might consider as its "ideal state". Implicit in the development of an Assessment Framework is development of a Management Framework for each stock which identifies how the stock might be managed. For example, assessment advice for a stock which is to be managed to provide a (perhaps) low but constant yield could be quite different from assessment advice to manage a pulsed fishery. The Objectives-based Fishery Management initiative within DFO should be helpful in this regard.

WORKING PAPER SUMMARIES, REVIEWS AND DISCUSSION

I2001-01: A phase "0" review of inshore tanner crab (*Chionoecetes bairdi*) biology

G. Krause
** Paper Not Accepted **

Reviewers' Comments

Reviewer #1

Reviewer #1 felt that although the paper contained useful information on *C. bairdi*, it would require substantial discussion and development to include recommendations, as well as substantial consolidation, reduction, and re-organization if it was to provide the necessary direction to further a potential fishery. This paper did not adequately focus the material or indicate its significance to precautionary development of a fishery in B.C. This paper failed to identify information gaps that need to be addressed before any fishery could take place and offered no recommendations based on the biological information presented that might impact future fishery development or management. The reviewer could not recommend acceptance of the paper in its present form.

Reviewer #2

The paper is missing the crucial objective of a Phase 0 review, which is to identify information gaps. This objective is critical to the development of a commercial fishery, and the paper needs to propose methods for addressing those information gaps. Furthermore, the paper inadequately reviews the causes and consequences of major fishery collapses in Alaska that would have been relevant to the assessment of fisheries potential for this species in B.C. Much relevant recent literature and data are omitted which would have been made available had the author contacted the appropriate DFO staff. Parallels drawn between the existing fishery in SE Alaska and the proposed fishery for B.C. are not supported by the description of the SE Alaskan fishery presented. Finally, the paper provides no useable recommendations. The reviewer could not recommend acceptance of the paper.

Subcommittee Discussion

The Subcommittee discussed the objectives for a Phase "0" literature review and whether this paper met these objectives. The Subcommittee determined that this paper did not meet these objectives. In particular, the paper omitted consideration of critical information gaps and how these critical gaps might be filled. The paper also did not consider available information on the Russian snow

crab fishery, more details on the Alaska experiences and pertinent stock collapses there, and other information from British Columbia. The Subcommittee concluded that the paper represented a good start on reviewing the biology of this species, but that it was still a work in progress and that internal departmental staff needed to be contacted to assist in developing it to an acceptable Phase "0" document.

The Subcommittee was concerned that the document had been presented at PSARC without going through the appropriate process for submission of PSARC working papers.

Subcommittee Recommendations

1. The Subcommittee could not accept the paper in its present form. The Subcommittee felt that the paper had not been originally written as a phase "0" report and as such missed a number of crucial aspects.

2. The Subcommittee recommended that this species be evaluated within the prioritisation model for new and emerging species. Depending on its ranking, the author was encouraged to work with departmental staff to develop this paper into a phase "0" document.

I2001-02: Results of surveys of intertidal razor clams (*Siliqua patula*) on beaches near Massett, Haida Gwaii and recommendations on fishery management

R. Jones, C. Schwarz, B. DeFreitas, and L. Lee
**Accepted subject to revisions **

Summary

Intertidal razor clam populations and biomass on beaches near Massett, Haida Gwaii were estimated using a three stage sampling design stratified by beach section for the period 1994 to 2000. The 2000 year razor clam populations on 18.8 km of beach accessible to the commercial fishery were estimated by the ratio method to be 36,100,000 (CV 19%) clams $\geq$ 4 mm, 22,400,000 (CV 8.5%) clams $\geq$ 20 mm, and 11,800,000 (CV 22%) clams $\geq$ 90 mm). Estimates using the inflation method in 2000 were similar, at 36,200,000 (CV 14%) clams $\geq$ 4 mm, 23,000,000 (CV 26%) clams $\geq$ 20 mm and 12,500,000 (CV 8%) clams $\geq$ 90 mm. The two methods varied considerably in some years mainly due to assumptions about average transect length (and the area of the beach). The inflation method estimate provides a lower bound on the estimates since it is based on the actual length of the transect which was found to vary between years. The 2000 biomass of clams > 90 mm was estimated to be 1757 t (SE 161 t). Age-at-maturity studies showed that razor clams do not start to mature until they reach 80 mm and most are mature at 97 mm. The surveys show that the biomass was at a

historic high in 2000 and that a large number of two year old clams were in the population, most of which will recruit to the fishery in 2001.

Reviewers' Comments

Reviewer #1

This reviewer welcomed the working paper and stated that its results should assure Fishery Managers that recent high landings were not excessive in the short term. He felt that the paper met its stated objectives, and that the results reflected the uncertainties in the data. He noted that data presented in the paper suggests that the 90 mm size limit was not meeting its objectives, and suggested that if size at maturity was a concern, raising the size limit might be considered. He further noted that the data suggests the 90 mm size limit may not be precautionary. This reviewer also emphasized the importance of age information and supported the practice of collecting samples of clams each year for aging. He noted that yields might drop precipitously when abundance declines, which might require additional management responses such as effort limits.

Reviewer #2

This reviewer indicated that the purpose of the paper was clearly stated and that the advice reflected the uncertainties in the data. He suggested that further details of the survey design and methods were required. In particular, he was concerned about the apparent practice of ending transects at high elevations of the beach when low abundances of clams were found, rather than continuing the transect to cover the full width of the beach. He provided a number of other detailed comments for revision of the paper.

Subcommittee Discussion

Sampling design
There was discussion around the sampling design and data presentation and there were suggestions for providing more complete descriptions and refinements to some of the figures.

Size limits
There were concerns regarding removing or altering the size limit of 90mm, as suggested in the paper. The Subcommittee suggested that there should be a clear definition of the purpose of the size limit: is it to guard against recruitment and/or growth overfishing? (Data in the paper suggest the present size limit is similar to 50% maturity.) There may be a need for further data gathering and analyses prior to removing or altering the size limit. Different size limits may be invoked for economic rather than biological basis and additional management actions may be required if size limits were removed. The current and potential rates of discarding or breakage need to be taken into account when discussing

size limits. The size and ages vulnerable to the fishery need to be better documented to understand the impact of changes in the size limit. A closer look at growth rates and seasonality of reproduction is needed before defining a size limit that permits one season of spawning before capture in the fishery.

Reference Points
The Subcommittee noted that the exploitation rate developed in 1994 was based on a surplus production modelling approach. This was used to develop an MSY exploitation rate of 18.6%. Considerable fishery and survey data have been collected since 1994. These data should now facilitate updated modeling of this MSY value and updating of the exploitation rate. This will require completion of aging of samples collected to date.

Stock Status
The Subcommittee took note of evidence for good recruitment (in the form of abundant sub-legal age classes) in the most recent survey. The abundance of clams surveyed in 2000 was the highest observed over the past 7 years. There is additional beach area with clams that are outside the traditionally surveyed area that will contribute to the population – i.e. the biomass estimate from the recent fishery-independent surveys appears to be conservative.

Subcommittee Recommendations

The Subcommittee accepted the paper subject to revisions.

1. The Subcommittee accepted the results of the analyses indicating a large biomass of razor clams was present in 2000 and that the 2001 catch ceiling (235.8 t) was within the range of estimates based on a 12.3% harvest rate (160 - 237 t, which is based on 2/3 of the 1994 MSY estimate).

2. The Subcommittee recommended that the data collected since 1994 should be analysed to re-evaluate the estimate of MSY from the North Beach razor clam stock, and that the collection of density and age data should continue in support of future refinements.

3. Until such revision and reanalysis of reference points in this fishery, the Subcommittee recommended using the 12.3% harvest rate and applying this to the current year biomass estimates to obtain current catch ceilings. When managers set actual catch ceilings, they should consider additional information such as recruitment, and surveyed area relative to fished area, etc.

4. The Subcommittee does not support removing the size limit without considering the implications or reasons for doing so (economic and/or biological). Additional data may also be needed to define a biological basis for the size limit.

I2001-03: High levels of genetic variation in northern abalone, *Haliotis kamstchatkana*, of British Columbia

R. Withler, A. Campbell, S. Li, K.M. Miller, D. Brouwer, and B. Lucas
Accepted subject to revisions

Summary

Northern abalone (*Halictis kamtschatkana*), from 18 sites in British Columbia and one site in southeastern Alaska, were surveyed for variation at 12 polymorphic microsatellite loci. In all samples, levels of observed heterozygosity were high (H_o = 0.64-0.74) but lower than values expected (H_e = 0.88-0.90) under conditions of Hardy Weinberg equilibrium (HWE), due to heterozygote deficiencies at all 12 loci. Levels of excess homozygosity varied more among loci (f_{is} = 0.02-0.55) than among samples (f_{is} = 0.16-0.28), indicating that inbreeding alone did not account for the large homozygote excess observed at some loci. Based on the six loci at which genotypic frequencies were closest to HWE expectations, the estimated level of inbreeding in northern abalone aggregations is 0.06. The high level of H_e characterizing all samples resulted in a large estimated effective population size for northern abalone (420,000), consistent with a high estimate for the historical average number of migrants entering abalone aggregations each generation (~20). Hierarchical analysis of gene diversity revealed that 99.6% of genetic variation was contained within abalone samples and only 0.4% partitioned among samples. Approximately 0.2% of variation was accounted for by differentiation between abalone of the Queen Charlotte Islands and Alaska and those found in central and southern British Columbia, and the remaining 0.2% was due to differences among samples within each of those two regions. The results indicate that, historically, northern abalone aggregations did not represent isolated breeding units and any disruption of gene flow that may have been caused by recent low abundance levels cannot yet be detected in non-size-structured samples of adult abalone.

The study makes the following recommendations:

1. preserve existing brood stock *in situ*, perhaps establishing a number of reserve areas where increased protection of local aggregations is possible
2. techniques such as artificially aggregating adult abalone in areas of low density or the out-planting of hatchery-reared juveniles may be useful, but would require careful monitoring for evaluation
3. establish study sites in which larval dispersal, recruitment and microspatial and temporal genetic variability could be monitored to enable greater understanding of the current population genetics and demographics
4. limit transplantation or aggregation of abalone to within existing management areas (WCVI, ECVI, Central BC, QCI) until more is known of adaptive genetic variation and disease issues

Reviewer's Comments

Reviewer #1

The reviewer felt that the paper was clearly written and the results thoroughly analysed. This reviewer had two major comments:

Firstly, the working paper stated that the results are contrary to Hamm and Burton in which stocks of certain species of abalone in California were found to constitute separate populations. The reviewer agreed that *H. kamtschatkana* might be expected to show more structure based on its seasonal reproduction although that would depend on the extent to which the oceanography of the B.C. coast changes seasonally. There are dramatic seasonal changes in current patterns along the California coast. Is this true for B.C.? More background on seasonal oceanographic patterns for the B.C. coast may be needed.

Secondly, mtDNA work may be better suited (than microsatellite) to look at historical issues raised on p. 11 of the working paper. The reviewer felt that the only conclusion not justified by the data was the suggestion that refugial populations (if they existed) failed to diverge genetically. mtDNA might reveal old lineages that diverged in refugia.

This reviewer felt that future work should focus on microspatial and temporal monitoring in order to assess patterns of recruitment.

Subcommittee Discussion

The Subcommittee discussion first focused on the reasons explaining the potential genetic differences between abalone from the Queen Charlotte Islands and abalone from the rest of the B.C. coast. The first reason may be that the Queen Charlotte Islands are isolated geographically which would restrict gene flow. A second possibility is that the Queen Charlotte Islands may have been isolated from the rest of B.C. and act as a refuge for abalone during the last glaciation era. The rest of the coast may have been re-populated from populations from more southerly locations after the glaciation era ended. Although mtDNA may be useful in looking at historical patterns, the author felt that there were no indication in the data that the populations ever got low enough so that the mtDNA would resolve the issue of whether there are two abalone stocks or one in B.C.

Part of the goal of the study was to determine if DNA can be used to identify where abalone from unknown sources (e.g., abalone seized from illegal fishing operations) came from. The author was pessimistic due to the high degree of variability within samples and low degree of differentiation between samples. However, ongoing work will analyse a series of second samples, collected from some of the same areas as the initial samples, which will help answer the

question of stock identification.

Large abalone act as a bank of genetic diversity. The study was comprised mostly of adult abalone and therefore was a snapshot of the last 10-40 years history. The potential effects of the recent isolation of populations on northern abalone genetics in B.C. may therefore have been masked. Genetic monitoring is needed in order to determine the effects of the current levels of abundance. Historically, there has been larval flow for northern abalone in B.C. Monitoring is needed to determine if this is still the case at the current levels of abundance and geographic population isolation.

The possibility that genetic variability could occur on a smaller scale than that at which samples were collected was discussed. Due to the scarcity of northern abalone, the sample collections sometimes had to be made over fairly large areas. However, since the genetic variability was so large, there was no suggestion of very small-scale differences. If very small-scale differences were present, over time, they should lead to large-scale differences, which were not observed here.

Questions were raised about the heterozygote deficiency at all loci and whether it could be due to sampling bias. Two possible reasons for the heterozygote deficiency were: 1) locus-specific problems (e.g. some alleles not being amplified), or 2) some loci may have been located on a sex chromosome therefore registering as homozygotes. The author remarked that heterozygote deficiency is common in abalone species and felt that using only the best 6 loci gave a better estimate of inbreeding since this eliminated locus-specific problems.

The Subcommittee discussed the genetic implications of seeding cultured abalone to wild populations. If brood stock is taken locally, seeding may not disrupt the genetics of a population. Since there is a large degree of genetic variability within locations, there is a risk that genetic variability may be limited if only a small number of animals are used as brood stock (or if only a few brood stock animals successfully spawn) therefore under-representing the variability found in the local area. Furthermore, selective forces under hatchery conditions may lead to genetic variation. Thus, there is a need for genetic monitoring of seeding projects.

The Subcommittee noted that one objective requested in the original request for the working paper was whether DNA analyses can be used to distinguish northern abalone from other species of abalone and was not included in this paper. The authors indicated that work on this topic is on-going and will be presented as a separate paper at a later date.

Subcommittee Recommendations

The Subcommittee recommended the paper be accepted subject to revisions.

1. The Subcommittee accepted the recommendations from the paper regarding preservation of existing brood stock *in situ*; monitoring and evaluation of out-planting techniques; and establishment of study sites for monitoring current population genetics and demographics.

2. The Subcommittee concurred with the paper in recommending that brood stock collections be made within the general regions into which seeding is intended to take place.

I2001-04: Assessment of green sea urchin *(Strongylocentrotus droebachiensis)* stocks in British Columbia, 2001

R.I. Perry, B.J. Waddell, and Z. Zhang
Accepted subject to revisions.

Summary

This paper (i) provides an analysis of the green sea urchin fishery in British Columbia by updating information from the fisheries in 1998, 1999, and 2000 fishing seasons; (ii) provides suggestions for limit and target reference points for the 2001-2002 and 2002-2003 fishing seasons; and (iii) presents results from fishery-independent surveys of green sea urchins. Reference points were determined using biomass dynamic models developed for the core stocks in the South Coast – inside waters northern region (Queen Charlotte Strait; Pacific Fisheries Management Areas 11-13) and the South Coast – inside waters southern region (Gulf Islands; PFMA 17-20,28). Two methods were used to determine the parameters of these models: a linear approximation to the dynamic Schaefer model, and a time series fitting method. For both core stocks, both models produced similar (i.e. overlapping 95% confidence intervals) estimates of the maximum sustainable yields (MSY). The time series fitting method produced a lower MSY with narrower confidence intervals for the smaller stock (Gulf Islands region), and it is recommended as the more conservative method for calculating reference points. The calculated MSYs are recommended as limit reference points, with target reference points suggested in the range of 0.25 to 0.50 of MSY. The resulting target reference range for both core regions in the South Coast is therefore 96.3 to 192.5 t. Fishery-independent surveys have been conducted annually since 1995 at index sites in Area 12 (Queen Charlotte Strait) and indicate that the biomass of legal and sub-legal sized green urchins in this area in 1999 and 2000 were among the highest observed. Fishery-independent surveys in the Gulf Islands region have been conducted for two years. They show inconclusive trends in legal-sized biomass between the two key locations, but all locations appeared to have strong sub-legal sized biomass.

Reviewers' Comments

Reviewer #1

This reviewer felt this was a good paper which contributes to Canadian expertise for management of the green sea urchin fishery. The reviewer commented that to her knowledge, with the exception of short Stock Status Reports, this paper (and its previous versions) are the only detailed assessments available to date of green sea urchins in Canada. The objectives were clearly stated, and the methods presented clearly and in sufficient detail. Reasons why the time series fitting method were introduced in this assessment were not well explained. The interpretations of the results and the final recommendations were cautious and took into account the uncertainties associated with the models and data.

Reviewer #2

Reviewer # 2's major concern was that catch-per-unit-effort (CPUE) is used to estimate maximum sustainable yield for green urchins. Highly aggregated species (such as green urchins) are vulnerable to serial depletion and CPUE is poor at detecting serial depletion. This assessment gives no justifiation for using CPUE. Even if CPUE is the best abundance-indicator from the available data, that needs to be stated in the paper. For future assessments of green urchin stocks, this reviewer recommends that either CPUE be justified or that better indicators of abundance be found.

The assessment does present some estimated biomasses based upon survey results but there is no comparison of results from the survey and the CPUE analysis.

The reviewer also believed there were technical errors in the calculation of CPUE and the way uncertainty was assigned in the models. However, he did not expect these errors to have a major impact on the quota calculations.

Subcommittee Discussion

Subcommittee discussion centred on the risk of relying on CPUE as an index of abundance for an aggregated sedentary species such as green urchins, e.g. concerns over serial depletion. Factors that may affect CPUE (in addition to changes in stock abundance) were also identified, for instance variable roe quality and market demand. The authors state that over the most recent three years of fishery data there is no evidence of serial depletion that would keep the CPUE at artificially high levels. Concern was expressed that response of CPUE in fishery 'hotspots' would not be the same as for other less productive areas, however since the CPUE index is calculated from all data from the fishery, it was felt that this was not a large concern. The value of conducting a spatial analysis of the historical fishery data to look for evidence of serial depletion was clear.

The accuracy and reliability of fishery data has improved over the past years due to cooperative relations with industry, and there was optimism that a spatial database from early fishery records could be constructed.

Since the green sea urchin fishery exploits small discreet populations and is relatively low value, direct estimation of current biomass may not be cost effective. The Subcommittee therefore accepted the use of the biomass dynamic modelling approach. The history of the green sea urchin fishery has produced CPUE and effort data that contain sufficient contrast for these model approaches to work. Additional information to estimate current biomass might be gained from comparisons of estimates from different methods to look for evidence that CPUE is proportional to abundance, for instance, a comparison of fishery-independent estimates of biomass at surveyed sites to estimates of biomass derived from the ratio of CPUE and catchability for these sites.

Further on the CPUE issue, the Subcommittee discussed whether the driving force behind historical stock declines (and therefore CPUE) was natural fluctuations in recruitment rather than a response to fishing effort. This was based on the premise that the fished populations are surrounded by unfished reserves of breeding individuals, and therefore CPUE indexes a larger population than is being fished. The authors felt that, while there exist many small pockets of green sea urchins, the fished areas constitute the major population aggregations, and that large-scale recruitment is unlikely to come from other sites. Also, recent survey results show recent strong recruitment in all areas.

The Subcommittee discussed a need for decision rules to help guide management when provided with a range of target yield options. Future assessments could include a risk assessment that would provide a better guide for management decisions. At the least, the working paper should include a summary of management decisions made in the recent past regarding the choice of target reference points.

The Subcommittee discussed the value of assessment frameworks to identify the information and research requirements for potential fishery expansion. Indeed, such frameworks should be developed for all invertebrate fisheries, and advantages could be further gained by combining, comparing and contrasting requirements within similar taxonomic groups. These frameworks should include other options to gather information than those currently in place, such as experimental fisheries.

The Subcommittee agreed with the authors that there are no major concerns with the green sea urchin fishery, given recent good recruitment seen in fishery-independent surveys and increased density and CPUE, but qualified this optimistic view with a recognition of the weaknesses in using CPUE as an index of abundance.

Subcommittee Recommendations

The Subcommittee accepted the paper subject to revisions.

1. The Subcommittee endorsed the recommendations in the paper of target yield points in the range of 0.25 to 0.50 of MSY (96.3 to 192.5 t for all areas combined).

2. The Subcommittee supported the recommendation that fishery-independent surveys should continue in Area 12; that a site should be selected to develop annual surveys in the Gulf Islands areas; and that experimental studies on growth rates and age determination should continue. However, a rationale should be provided in the paper that clearly explains the benefits of these programs.

I2001-05: Status of manila clam (*Venerupis philippinarum*) stocks in Area 7, with a proposal for active management of a data limited fishery

G.E. Gillespie, T.C. Norgard, and F.E. Scurrah
Accepted subject to revisions.

Summary

The Area 7 intertidal clam fishery has been active since 1992, resulting in production of over 600 t of Manila clams. The fishery was managed using an arbitrary total allowable catch (TAC) of 113.6 t (250,000 lb) until review in 1999, when the TAC was reduced to 68.2 t (150,000 lb). An assessment program was developed in 1999 that identified important beaches within each subarea that was heavily fished and these beaches were surveyed in both 1999 and 2000.

Four of five subareas assessed exhibited declines in legal biomass from 1999 to 2000, as did the overall aggregate biomass of all index beaches in Area 7. This paper examines the application of the Magnussen-Stefansson feedback gain model to the first two years of data collected. Two options are discussed – adjustment of the overall Area 7 TAC based on the aggregate results and establishment of harvest thresholds for individual subareas, which would allow opportunity to harvest the remainder of the TAC from underutilized subareas.

The paper recommends that managers consider adopting the second option (subareas thresholds), with a review of the appropriateness of index beaches currently assessed, establishment of index beaches in subareas not currently assessed, and that managers and harvesters acknowledge that continued reductions in subarea thresholds will require re-assessment of the overall Area 7 TAC.

Reviewers' Comments

Reviewer #1

This reviewer had no major criticisms with the paper, which he felt was well presented, clear, and succinct. He agreed with the selection of index beaches, and felt they provided the best general picture of the situation. He noted that recruitment in this population (at its extreme northerly distribution) is likely to be erratic and will be a major factor in the short-term fishery yields. He questioned the ability of remote beaches to sustain augmented landings to help the fishery reach its TAC, since recruitment in these areas may be more erratic than other areas, and a decrease in the overall TAC may be more appropriate. As a result of fluctuating recruitment, the reviewer agreed with the management suggestions to sustain annual landings.

Reviewer # 2

This reviewer felt the paper was well written. The information it contains supports the recommendations, which are in a form useful to managers.

Subcommittee Discussion

The Subcommittee noted that this fishery is co-managed with the Heiltsuk Tribal Council, who were active participants and co-authors in the assessment work. The Subcommittee was highly complimentary to the authors and the Heiltsuk Fishery program for their successful efforts at introducing logbook and monitoring systems into this fishery, and for implementing the fishery-independent survey program.

The Subcommittee discussed whether there is a good inventory of Area 7 beaches, and if so, if their approximate sizes are known. It was noted that representative index beaches are very important for the assessment and management of the Area and its subareas. The Subcommittee also discussed the need for defined guidelines or criteria for the selection of index beaches. There may be a need to consider more than one index beach needed per subarea (this is already being done for some subareas). The authors and members of the Fisheries Program of the Heiltsuk Tribal Council replied that the locations are known, however not all sizes of the beaches are known, and that mapping is scheduled to commence this summer.

The Subcommittee discussed the fact that recruitment differed among beaches even within the same subarea. Reasons for these differences could include oceanographic processes. Although this was not specifically addressed in the paper, it was discussed that Area 7 is at the northern most limit of its range and that oceanographic conditions can strongly influence recruitment and should be considered in the assessment and management processes. It was also noted

that oceanographic conditions during the past two years have been different (colder) than conditions through most of the 1990s, which may adversely affect recruitment. It is unclear how large scale oceanographic trends translate to small scales and to local ocean conditions, and therefore how they may affect local recruitment processes. Recruitment variability must be taken into account when deciding whether to assess and manage subareas as a whole, or whether other management units, either portions of subareas or two or more subareas combined, are more appropriate.

The Subcommittee noted that outer beaches may not be able to support the TAC if beaches nearer to settlements continue to show signs of stress. Perhaps the different responses of these beaches to oceanographic changes (in comparison to protected "inside" beaches) may also adversely affect their recruitment.

A substantial portion of the discussion focused on the need for defined management objectives. For example, is the focus on a sustained and consistent harvest or a pulse fishery. Having a defined management framework when designing the assessment framework would be beneficial. Survey and landings data from the early years of the fishery were of limited utility due to inconsistencies in survey design resulting in biases in means and variance.

The Magnussen-Stefansson feedback gain model is appropriate for the determination of reference limits because of the limited data available. In the future, when more data are available, it will be important to examine alternative models. These reference points were suggested as maximum thresholds; when they are reached an area should close, with no overages allowed. Both values for the "gain factor" represent a range of options for these reference points.

Subcommittee Recommendations

The Subcommittee accepted the paper subject to revisions.

1. The Subcommittee accepted the recommendations from the paper. These concern adopting subarea in-season catch thresholds, a review of the appropriateness of current index beaches, establishment of index beaches in subareas not currently assessed, and acknowledgement that continued reductions in subarea thresholds will require re-assessment of the overall Area 7 TAC.

2. The Subcommittee endorsed the use of the Magnussen-Stefansson feedback gain model for this fishery.

FISHERY UPDATES

The Subcommittee discussed the future role and value of having fishery updates presented at the Invertebrates Subcommittee of PSARC. It was recognised that

much of the information that now appears in fishery updates is included in a number of other internal documents such as Integrated Fishery Management Plans, etc. Concern was expressed about multiplication of effort and information. The Subcommittee was in agreement over the value of the information in these fishery updates, in particular as a record of actions taking in each fishery. However, the Invertebrates Subcommittee of PSARC may not be the optimal committee to receive these documents. The documents may be more appropriate for discussion at the Shellfish Working Group of DFO. Consequently, an *ad hoc* working group of 4-5 people under the direction of J. Rogers was struck to consider:

1) the optimal format for these Fishery Updates (i.e. type of information to include, similar presentation format, etc.);
2) the optimal venue for presentation of these updates; and
3) the optimal means to archive these updates so that they are available to those who need them and they are up to date.

Euphausiids

The 2000 year fishery commenced January 03, 2000 as per the Euphausiid 2000/2001 Management Plan. The season concluded November 17, 2000 as the overall 500 tonne quota had been achieved. The industry funded "hail in and dockside validation" program initiated in 1997 was again successful in effectively monitoring the activity and area quotas assigned to the fishery.

Eleven of the nineteen licences eligible to participate in the fishery reported landings in 2000. Rates of catch were higher in January and November 2000 than those observed in January and November of 1999. The increase in rates of catch observed in the fishery was consistent with a significant increase in abundance of euphausiids noted in the surveys conducted in 2000. The 2000 year survey results are as yet unpublished but suggest a doubling of the biomass over 1999 levels. The report on this survey (as yet unpublished) anticipates that major changes may occur in the dynamics of the Strait of Georgia ecosystem as the increased production of euphasuiids and other plankton are incorporated into other trophic levels. The licenced commercial fishers remain interested in pursuing scientifically based and responsible options that lead to increases in the overall quota available to the fishery. The majority of license holders also support and are interested in the implementation of individual vessel quotas (IVQ's) to further stabilise and to optimise the economic returns in the fishery.

The Subcommittee discussed the interest expressed by industry to increase the overall euphausiid quota. The Subcommittee noted that the current policy that limits further development of the fishery was implemented at a time when euphausiid biomass was at lower levels. The Subcommittee concluded that the current policy does not provide for expansion of the fishery above the current 500 tonne quota.

Sea Cucumber

The 2000 Sea Cucumber fishery was open from October 22 to 25. Following a density survey in Area 12, the coastwide total allowable catch (TAC) was 370.1 t (816,000 lb.), an increase of 5.5% from 1999. The TAC is divided equally among 85 license holders; each individual quota equaled 4.4 t (9,600 lb.). Fishers landed 371.9 t (819,804 lb.) of sea cucumbers; the small quota overage was relinquished to the Crown.

The fishery is managed through an adaptive management plan that opens approximately 25% of the coast to the regular commercial fishery. The remainder of the coast is reserved for research, experimental fisheries and long term refugia. Management issues have not changed over recent years. They include: ongoing consultation to ensure First Nations' access; a desire by the commercial industry to stack more than the currently permitted three licences per vessel; educating the fleet on appropriate fishing notification methods and reporting of commercial harvest information; concentration of fishing effort; and gathering basic biological data. All issues are being addressed in collaboration with the Pacific Sea Cucumber Harvesters Association and coastal First Nations.

Intertidal Clams

The total clam catch for all species in 2000 was 1,546 t, valued at $4.7 million, as compared to 1,638 t (value $5.3 million) in 1999. The lower result in 2000 was due mostly to changes in management strategies on the West Coast of Vancouver Island and closures due to public health issues. Continued poaching and illegal harvests, remain major issues for the East Coast of Vancouver Island. Priority issues are management actions in the face of illegal harvests, the poor state of saleslip data, and development of opportunities for varnish clams. In addition, a major concern is Provincial aquaculture expansion and its impacts to wild harvest opportunities for clams and recreational harvests.

Shrimp by trawl

The most significant in-season management issues in the 2000/01 shrimp trawl fishery were the bycatch of eulachon off the west coast Vancouver Island (WCVI) in relation to precautionary bycatch action levels and the closure of Queen Charlotte Sound due to eulachon conservation concerns. Shrimp landings were reportedly affected coastwide by poor market conditions, early gear restrictions and in-season interruptions to WCVI fishing opportunities on reaching eulachon action levels, subsequent shutdown of the west coast processing plant and the closure of Queen Charlotte Sound for eulachon conservation concerns in the central coast. In spite of increased shrimp abundances offshore, coastwide shrimp landings in 2000/01 were down compared to 1998/99 and 1997/98. The total annual allowable catch for all areas (excludes the west coast Vancouver Island offshore) decreased over 1999/00 and 1998/99; although if Queen

Charlotte Sound had opened, it would have seen an increase. The fishery-independent survey indicated significant losses in fishing opportunities with the closure of Queen Charlotte Sound. Preliminary reports indicate a significant decrease in the number of active vessels over previous seasons (153 of 248 licences). Offshore WCVI remains the major B.C. shrimp fishery. The strong year class of juvenile shrimp observed off the west coast of Vancouver Island in the May 1999 survey was present again during the May 2000 survey and contributed to an overall increase in the shrimp biomass estimate. However, WCVI catches did not reach expectations with early gear restrictions and in-season closure for assessment of eulachon abundances and bycatch. Since the current management regime was introduced in 1997, the annual landed value of the shrimp trawl fishery ranged between $5.3 and $5.8 million over 1997 – 1999 (peaked at $13.7 million in 1995). The initial calculation of landed value for 2000/01 fishery indicates a decrease to $4.1 million.

The fishery-independent survey indicates significant abundances of shrimp and eulachon off WCVI in 2001, however, precautionary eulachon action levels will likely curtail the fishery even with the mandatory use of eulachon reduction gear. Combined with low pink shrimp prices, increased interest and effort can be expected on other non-pink shrimp species (i.e. sidestripes, humpbacks, and coonstripes) that fetch a higher price per kilogram. Humpback and coonstripe fisheries have been restricted to date to follow the phased approach to fisheries with limited stock assessment information.

Goose Barnacle

Experienced harvesters were permitted to harvest and market goose barnacles to Spain as part of the Stock Assessment studies of the impact of harvesting. Harvesters from the two harvesters' associations participated in biomass estimates and were permitted to harvest from specific sites under scientific license. A fishery monitor was present to document discards and validate the quantities harvested. Harvests were conducted over 23 days by 3 to 6 harvesters for a total of 64 fishing days. There were five shipments marketed to Spain for a total of 1.4 tonnes with a gross landed value of $20,900 ($13.20 per Kg). A Goose Barnacle Working Group continues to be involved with these studies. Stock Assessment data gathering is continuing to define the impact of this fishery on the sea mussel beds and the goose barnacle stocks and will conduct field activities in 2001. A report on the impact of goose barnacle harvesting is expected for 2002.

STOCK STATUS REPORTS

Three stock status report were reviewed and approved by the Subcommittee: Green Sea Urchin, Manila Clam, and Razor Clam. Once reviewed and approved these stock status reports will be forwarded to the PSARC Secretariat for publication in the usual manner.

APPENDIX 1: PSARC INVERTEBRATE SUBCOMMITTEE MEETING AGENDA, 19-21 JUNE, 2001

	19 June Tuesday *Start 0900*	20 June Wednesday *Start 0900*	21 June Thursday Start 0900
AM 1	Introduction and Procedures I2001-04 (Green sea urchins)	I2001-03 (Abalone genetics)	Fishery update for: Clams
Break			
AM 2	Green Sea Urchin SSR update Goose barnacle Fishery update	I2001-05 (Area 7 Manila clams)	Emerging Issues Rapporteur's Reports Close
Lunch			
PM 1	I2001-01 (Inshore Tanner crab Phase 0)	Area 7 Manila clams SSR	
Break			
PM 2	Fishery Updates for: Euphausiids Shrimp trawl Sea cucumber	I2001-02 (Razor clams) Razor clams SSR	

APPENDIX 2: PSARC INVERTEBRATE WORKING PAPERS AND REVIEWERS FOR JUNE 2001.

No.	Title	Authorship
I2001-01	A phase "0" review of inshore tanner crab biology	G. Krause (Oweekeno First Nation)
I2001-02	Results of surveys of intertidal razor clams (*Siliqua patula*) on beaches near Massett, Haida Gwaii and recommendations on fishery management	R. Jones C. Schwarz B. DeFreitas L. Lee
I2001-03	High levels of genetic variation in northern abalone, *Haliotis kamstchatkana*, of British Columbia	R. Withler A. Campbell S. Li K.M. Miller D. Brouwer B. Lucas
I2001-04	Assessment of Green Sea Urchin (*Strongylocentrotus droebachiensis*) stocks in British Columbia, 2001	R. I. Perry B.J. Waddell Z. Zhang
I2001-05	Status of manila clam (*Venerupis philippinarum*) stocks in Area 7, with a proposal for active management of a data limited fishery.	G.E. Gillespie T.C. Norgard F.E. Scurrah

Reviewers for the PSARC papers presented at this meeting are listed below, in alphabetical order. Their assistance is invaluable in making the PSARC process work.

N. Bourne	DFO, Pacific Region
R. Burton	University of California
G. Gillespie	DFO, Pacific Region
W. Hajas	DFO, Pacific Region
L. Pelletier	DFO, Institut Maurice Lamontagne
A. Phillips.	DFO, Pacific Region
J. Rogers	DFO, Pacific Region
G. Workman	DFO, Pacific Region
Z. Zhang	DFO, Pacific Region

APPENDIX 3: PARTICIPANTS AT INVERTEBRATE SUBCOMMITTEE MEETING, JUNE 2001

Subcommittee Chair: Ian Perry
PSARC Chair: Max Stocker

DFO Participants	Tues	Wed	Thurs
* Subcommittee Members			
B. Adkins*	✔	✔	✔
E. Bornhold	✔	✔	✔
J. Boutillier*	✔	✔	✔
N. Bourne		AM	
D. Bureau	✔	AM	✔
S. Campagna	PM	AM	✔
A. Campbell*	✔	AM	✔
D. Clark	✔	✔	✔
L. Convey	PM		
A. Drinkwater	✔	✔	✔
K. Fong	✔	✔	✔
G. Gillespie*	✔	✔	✔
W. Hajas	✔	✔	
C. Hand*	✔	AM	✔
R. Harbo*	✔	✔	
T. Johansson	✔	✔	✔
B. Koke	PM		
R. Lauzier*	✔	✔	✔
B. Lucas	✔	✔	
K. Marcus			✔
J. Moores*	✔	✔	✔
G. Parker*	✔	✔	
A. Phillips	✔	✔	✔
J. Rogers*	✔	✔	✔
B. Rusch	✔	✔	✔
D. Rutherford	✔	✔	✔
K. Smith		✔	✔
B. Waddell	✔	✔	
R. Webb			✔
K. West*	PM	✔	✔
R. Withler		✔	✔
G. Workman	✔	✔	✔
Z. Zhang	✔	✔	✔

External Participants:	Tues	Wed	Thurs
B. Heath* (B.C. Ministry of Fisheries)	✔	✔	
R. Jones (Haida Fisheries Program)	✔	✔	✔
B. MacPhee (Heiltsuk Fisheries)	✔	✔	✔
G. Krause	✔		

Observers:	Tues	Wed	Thurs
T. Norgard (Heiltsuk Fisheries)	✔	✔	✔
M. Callow (West Coast Green Urchin Association)	✔		
D. Kensall (West Coast Green Urchin Association)	✔		
C. Beggs (Heiltsuk First Nations)		✔	
G. Brown (Heiltsuk First Nations)		✔	